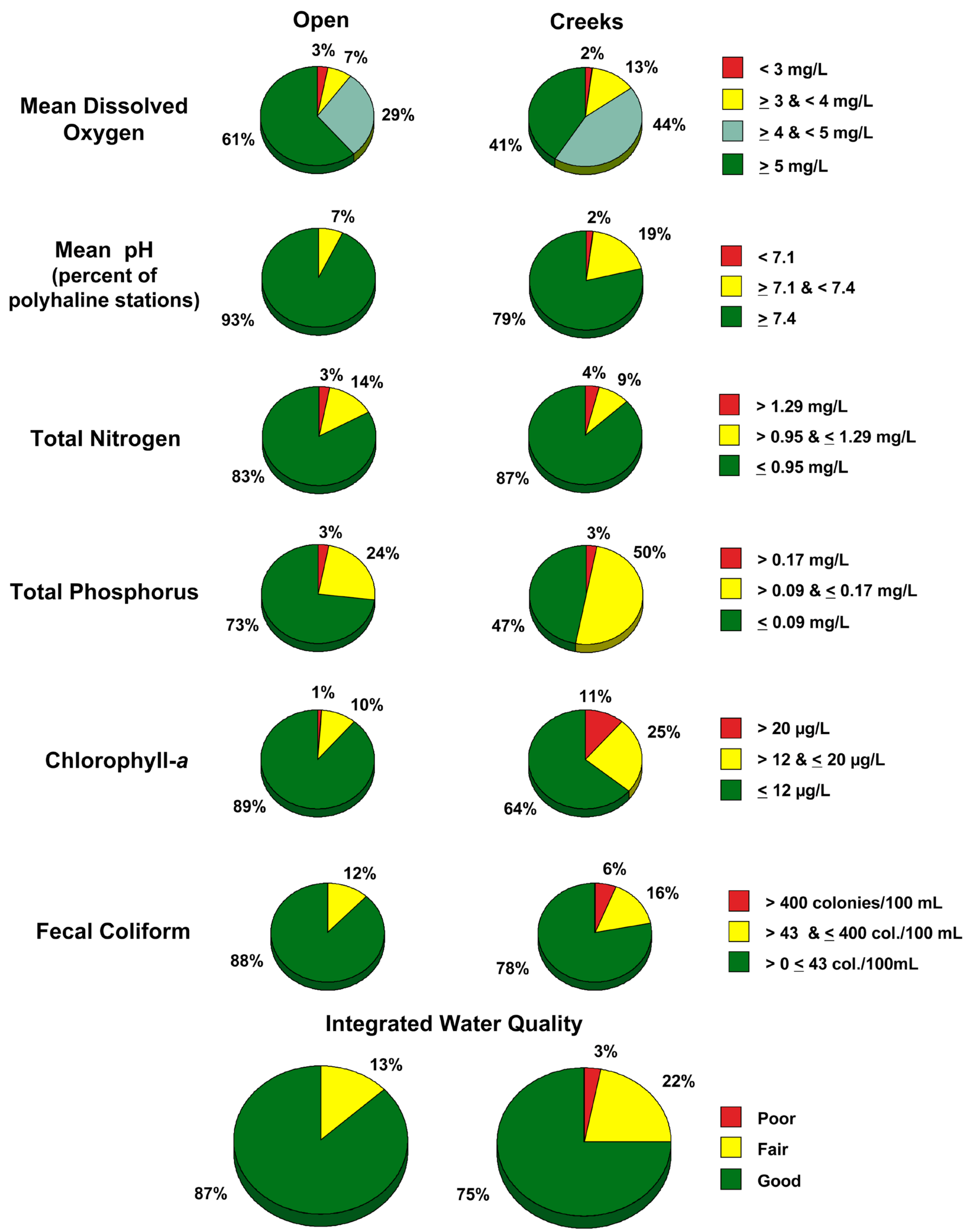

Figure 3.2.2. Comparison of the percent of the state's coastal habitat that represented various water quality conditions for selected water quality parameters and for the integrated water quality index.

habitat was considered to have good fecal coliform concentrations, 16% was not likely to be suitable for shellfish harvesting and 6% had coliform concentrations considered to be very poor and not likely to be suitable for primary contact recreation or shellfish harvesting (Figure 3.2.2). The locations of sites that had moderately high to very high fecal coliform counts are provided in Appendix 2.

Even though the mean values of fecal coliform concentrations were much higher in both habitat types compared to the 2001-2002 survey, there was not a substantial change in the percentage of the state's habitat that had undesirable bacterial levels (Figure 3.2.6) The higher fecal coliform counts observed in creek habitats is most likely due to the proximity of these small drainage systems to upland runoff from both human and domestic wastes as well as wildlife sources, combined with the lower dilution capacity of creeks compared to larger water bodies. Greater protection of tidal creek habitats is warranted in areas where upland sources of waste can be identified and controlled.

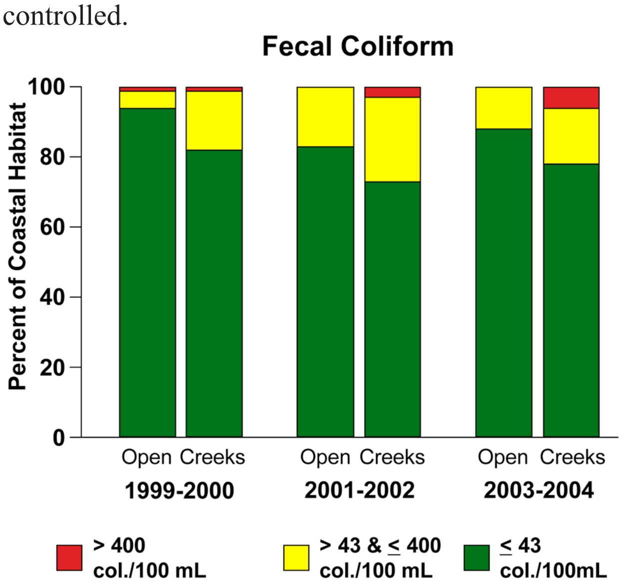

Figure 3.2.6. The percent of the state's coastal habitat representing various fecal coliform concentrations that are considered good (green), fair (yellow) and indicative of possible unsuitability for shellfish harvest, or poor (red) and indicative of possible unsuitability for primary contact recreation and shellfish harvesting during the three survey periods conducted to date.

Turbidity

Measures of water clarity provide an indication of the amount of suspended particulate matter in the water column. Exceptionally high turbidity levels may be harmful to marine life. South Carolina's estuarine waters are naturally turbid compared to many other states. SCDHEC has recently developed a maximum saltwater state standard for turbidity of 25 NTU. This corresponds to the 90th percentile of the SCDHEC saltwater database, which was obtained primarily from the larger estuarine water bodies. The 75th percentile of turbidity values obtained from SCECAP sampling was 15 NTU. Therefore for SCECAP, turbidity values ≤ 15 NTU are considered to be good, values > 15 NTU and ≤ 25 NTU are considered to be fair, and values > 25 NTU are considered to be poor because they contravene the SCDHEC standard.

While the SCECAP program recognizes the need to have turbidity standards, the standards are not incorporated into our overall water quality index at this time. Mean turbidities measured in the 2003-2004 survey by this program were 21.9 NTU in tidal creeks and 12.4 NTU in open water habitat (data online), which are very similar to the means noted in previous survey periods (Van Dolah *et al.,* 2002a, 2004a). As observed in the previous surveys, the difference between habitats was statistically significant ($p < 0.001$). Based on the single measure of turbidity taken at each station, approximately 29% of the tidal creek habitat exceeded the State standard, whereas only 7% of the open water habitat exceeded the standard (data online). Turbidity levels in tidal creeks may be naturally higher due to the shallow depths of these systems (i.e. surface samples are often within 1-2 m of the bottom) combined with re-suspension of the bottom sediments due to tidal currents. Because of the high turbidity levels observed in tidal creek habitats over the six years sampled by SCECAP (Box 3.2.1), this program has elected to not include this parameter in the integrated water quality index.

Integrated Assessment of Water Quality

SCECAP has developed an integrated measure of water quality using multiple parameters combined into a single index value (Van Dolah *et al*., 2004a). Six parameters are included in the index: dissolved oxygen (DO), pH, total nitrogen (TN), total phosphorus (TP), chlorophyll-*a* concentrations, and fecal coliform bacteria. DO and pH can indicate whether waters are stressful for many marine species. TN and TPs provide measures of nutrient concentrations, and combined with chlorophyll-*a* concentrations, these three parameters provide evidence of whether nutrient enrichment (eutrophication) may be occurring in South Carolina's estuaries. Fecal coliform concentrations provide an indication of the suitability of the water for shellfish harvesting and primary contact recreation.

Computation of the integrated water quality index is described by Van Dolah *et al*. (2004a; available online). For SCECAP, integrated scores > 4 represent good water quality conditions, scores > 3 but ≤ 4 represent fair water quality conditions, and scores ≤ 3 represent relatively poor water quality conditions, and scores .

Results of the 2003-2004 survey indicated that approximately 87% of the state's open water habitat had good water quality overall, 13% had fair quality, and none had poor water quality (Figure 3.2.2). In contrast, 75% of the state's creek habitat during this survey period had good, 22% had fair, and 3% had poor water quality. This was very similar to conditions observed in 2001-2002, which represented a drought period compared to the current survey. The creek sites with poor overall water quality were located in Rock Creek near the Ashepoo River and a tidal creek near Middleton Gardens in the Ashley River (Appendix 2).

As noted in the previous surveys (Van Dolah *et al*., 2002a, 2004a), the higher percentage of fair and poor water quality conditions in creeks indicates that these habitats are often naturally more stressful

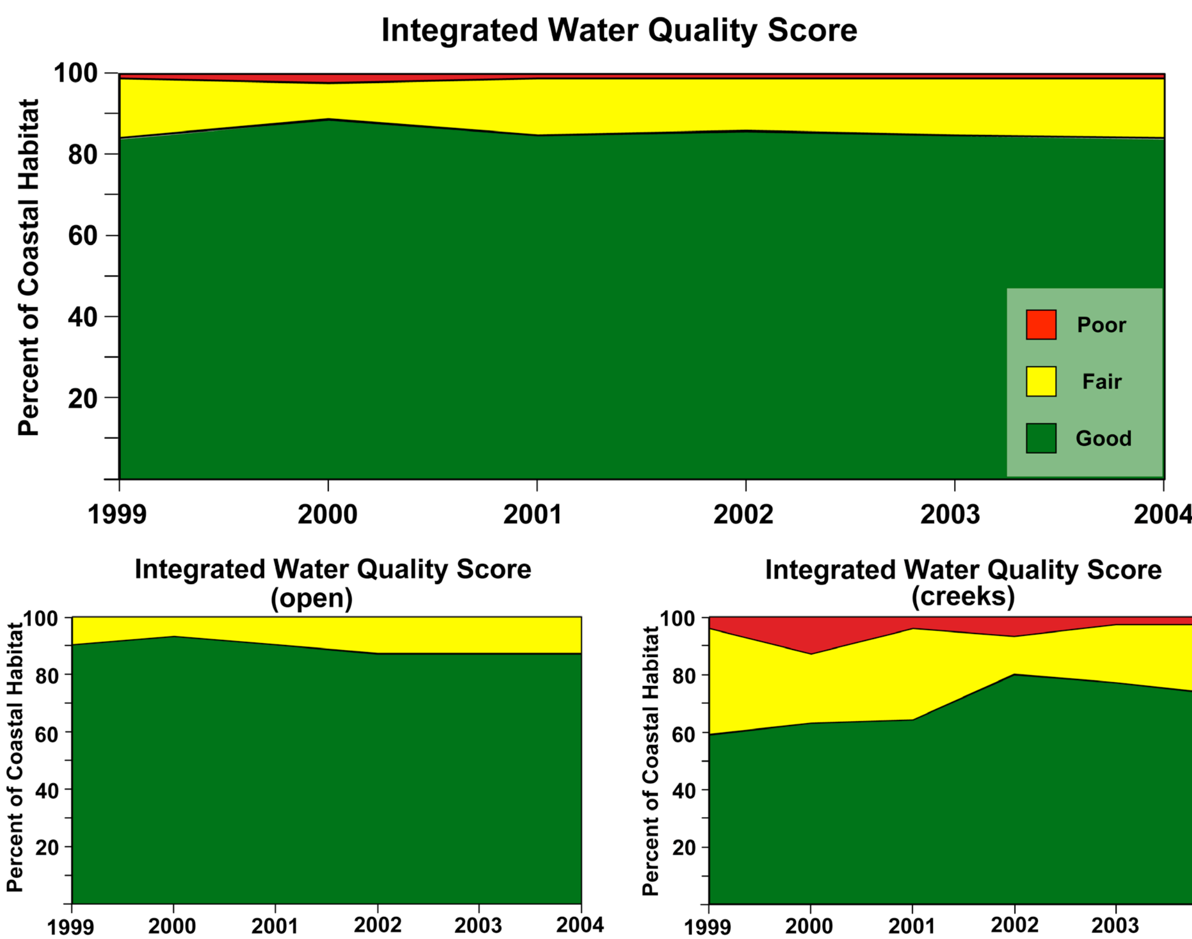

Figure 3.2.7. Proportion of the South Carolina's estuarine habitat that ranks as good (green), fair (yellow) or poor (red) using the integrated water quality score compared on an annual basis when tidal creek and open water habitats are combined and for tidal creek and open water habitats considered separately.

environments, especially since many of these sites were in relatively pristine locations. The higher percentage of creek habitat with fair or poor conditions may also reflect, in part, the relatively greater effect of anthropogenic runoff into these smaller water bodies due to their proximity to upland sources and their lower dilution capacity.

Comparison of the state's overall water quality condition on an annual basis indicated very little change over the six years sampled by SCECAP to date (Figure 3.2.7). This is surprising since the state's estuarine habitat was altered considerably by increased rainfall in 2003 and 2004 based on the changes in the proportion of the state represented by the various salinity zones (Figure 3.2.1). For all years, about 80% or more of the state's estuarine waters rank as good in quality using the SCECAP criteria, and generally less than 5% of the estuarine waters ranked as poor in quality. We anticipated that the increased rainfall experienced during 2003-2004 might have an impact on the state's overall estuarine water quality, but the resulting data did not confirm this. Although some of the component parameters did show evidence of considerable change, the actual concentrations observed among the various sites sampled in a given year, combined with the mitigating effects of those parameters that did not show much change, are the probable reasons for a lack in major changes in the integrated water quality index.

3.3 Sediment Quality

Sediment Composition

The composition of marine sediments can affect the structure of benthic communities, the exchange rates of gases and nutrients between the water column and seafloor, and the bioavailability of nutrients and contaminants to resident fauna (Gray, 1974; Graf, 1992). In general, muddier sediments (those with more silt and clay) tend to host a different set of species, reduce the movement of gasses and nutrients, and retain more contaminants than sandier sediments.

During the 2003-2004 monitoring period, sediments in open water habitats were on average 19.6% silt/clay while sediments in tidal creek habitats were 30.4% silt/clay, a difference that was significant ($p = 0.013$). Within each habitat type, the percent silt/clay was highly variable, with open water stations varying from 0.7-94.7% and tidal creek stations varying from 2.0-97.8%. The sediments at one open water station (2.0%) and four tidal creek stations (7.0%) had greater than 80% silt/clay (Figure 3.3.1). These values are similar to previous study periods (Van Dolah *et al.,* 2002a, 2004a).

Sediment Total Organic Carbon

Total organic carbon (TOC) represents a measure of the amount of organic material present in sediments. At very low TOC levels, little food is available for consumers resulting in a low biomass community; at very high TOC levels, enhanced sediment respiration rates lead to oxygen depletion and accumulation of potentially toxic reduced chemicals. Hyland *et al*. (2000) found that TOC levels below 0.5 mg/g (0.05%) and above 30 mg/g (3.0%) were related to decreased benthic abundance and biomass.

The TOC content of open water sediments averaged 0.8% while tidal creek habitats averaged 1.2%, a difference that was significant ($p = 0.048$). The TOC of open water habitats varied from 0.03% to 5.5% and that of tidal creeks varied from 0.05% to 5.5%. Based on the criteria in Hyland *et al.* (2000), the sediments were impaired with respect to TOC at 20% of open water habitats (14% too low, 6% too high) and 15% of tidal creek habitats (3% too low, 12% too high; Figure 3.3.1). These values are similar to previous surveys (Van Dolah *et al.,* 2002a, 2004a). The tendency of open water habitats to be characterized by lower TOC levels than tidal creek habitats likely reflects their greater distance from terrestrial sources of organic material.

Porewater Ammonia

Total ammonious nitrogen (TAN) provides a measure of the concentration of ammonia, a highly reduced and potentially toxic form of nitrogen, in marine sediments. Sources of ammonia include terrestrial runoff, atmospheric deposition and bacterial activity (nitrate reduction and ammonification), many of which are increasingly impacted by human activities, resulting in greater nitrogen loads in coastal environments (Driscoll *et al.,* 2003).

The median porewater ammonia concentration was 1.9 mg/L in open water habitats and 2.1 mg/L